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ABSTRACT

This paper describes structural equation modeling (SEM) in comparison with another overarching analysis within the general linear model (GLM) analytic family: canonical correlation analysis. The uninitiated reader can gain an understanding of SEM's basic tenets and applications. Latent constructs discovered via a measurement model are explored and the structural models that "connect" latent constructs are described. In addition to reviewing SEM constructs, the paper uses the analysis of a heuristic data set to show how SEM as the most general analytic approach subsumes canonical correlation analysis (CCA) as a special case, even though canonical correlation analysis in turn itself subsumes other parametric methods (e.g., t-tests, analysis of variance, regression, multivariate analysis of variance, and discriminant analysis) as special cases. An appendix contains an illustration that SEM subsumes CCA. (Contains 1 table, 4 figures, and 21 references.) (Author/SLD)

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Structural Equation Modeling versus Ordinary Least Squares Canonical Analysis: Some Heuristic Comparisons

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ABSTRACT

The present paper describes structural equation modeling (SEM) in comparison with another overarching analysis within the general linear model (GLM) analytic family: canonical correlation analysis. From the paper the uninitiated reader will gain an understanding of SEM's basic tenets and applications. Latent constructs discovered via a measurement model will be explored and the structural models that "connect" the latent constructs will be described. In addition to reviewing SEM concepts, via analysis of a heuristic data set the paper shows how SEM as the most general analytic approach subsumes canonical correlation analysis as a special case, even though canonical correlation analysis in turn itself subsumes other parametric methods (e.g., t-tests, ANOVA, regression, MANOVA, discriminant analysis) as special cases.

"Variables, variables, variables; why so many variables?"; thus Wampold (1987) begins his article on covariance structure analysis. In fact, multiple variables are more a reflection of reality than are events taking place in isolation, i.e., one independent variable influencing one dependent variable where both are observable. Indeed, with the complexity of most of the constructs found in behavioral and social research, measures that are useful for testing theories are frequently multidimensional and multidirectional. Thus, multivariate methods have become the panacea for questions of this sort (Thompson, 1994). And according to Wampold (1987), structural equation modeling (SEM, also called covariance structure analysis) is the "Gucci" of multivariate measures. Further, Lomax (1989) stated that "The development of methodologies to test hypotheses regarding the structure underlying covariance matrices [e.g., structural equation modeling] appears to be the single-most important contribution of statistics to the social and behavioral sciences during the past 20 years" (p. 171).

Jöreskog (1994) argued for the utility of structural equation modeling in solving many substantive research questions in the social and behavioral sciences. Further, he pointed out that the methodology underlying many 'different' models, e.g., simultaneous equations systems, linear causal analysis, confirmatory factor analysis, path analysis, structural equation models, recursive and non-recursive models for cross-sectional and longitudinal data, and covariance structure models, are in fact quite similar, if not exactly the same. The practice of giving different labels to the same processes has been previously revealed by Thompson (1995) as

an attempt "mainly to obfuscate the commonalities of parametric methods, and to confuse graduate students" (p. 87).

It is unclear whether the myriad labels applied to structural equation modeling is the sole, or only a partial reason why structural equation modeling continues to be misunderstood by many. This is in stark contrast to the statistical sophistication commonly applied to analyzing data by evaluating mean differences, correlational coefficients, tabular data and an occasional factor structure. Even though 10 years ago, Biddle and Marlin (1987) stated in reference to structural equation modeling that, "Misuse of these techniques have appeared in major journals. Users have made inappropriate claims for findings generated through these procedures and have applied them *mindlessly* in data analysis" (p. 4, italics added), these problems have persisted nonetheless.

The misconceptions and errors in applying and interpreting structural equation models are partially a result of these models being considered by many as "causal models" in the literal sense (Lomax, 1989). Causal modeling is thought to improve the ability to make causal inferences from field-study data. Because a predetermined statement of causal relationships among variables is required in structural equation modeling, one might assume that if a theoretical model "fits" data, then the fit is a function of causation (Biddle & Marlin, 1987). But in fact, evidence of a "fit" is merely an indication of an association and/or possible temporal relationship. As Biddle and Marlin (1987) stated: "Readers do not have to be reminded that correlation does not imply causality, [but in fact] causal modelers are occasionally *tricked* into this belief

by the word causal" (p. 9, italics added).

One other related semantic misunderstanding deals with the use of the term, "confirmed." Some of the users of structural equation modeling apparently erroneously believe that confirmation of model fit means "proof" that the model exemplifies reality and "truth," and further, that a confirmed model is exclusive in its explanation of the variables in question (Biddle & Marlin, 1987). Clearly, this is not the case. Confirmation of a model is one explanation of the model, but by no means is that model necessarily the only explanation of the variables. In fact, innumerable models may *all* fit a given data set, just as innumerable different models may also not fit the same data.

The present paper will delineate the underlying theory and application of structural equation modeling. Additionally, as it has been previously demonstrated that all classical univariate and multivariate methods are special cases (Fan, 1996; Knapp, 1978; Thompson, 1991) of canonical correlation analysis (Thompson, 1984), here a heuristic data set will be utilized to exemplify that structural equation modeling subsumes canonical correlation analysis. This will further support Fan's (1997) claim that, "Hierarchically, the relationship between the two analytic approaches [canonical correlation analysis and structural equation modeling] suggests that SEM stands to be a[n even] more general analytic approach" (p. 65).

Theory of SEM

A structural equation model consists of a measurement model and a structural model. The measurement portion of the model is an

attempt to explain relationships among a set of observations (i.e., "measured" or "observed" variables) in terms of a smaller set of unobserved variables (i.e., "latent" or "synthetic" variables) (Long, 1983). This is accomplished by utilizing factor analysis to reproduce the interrelationships among a set of observed variables through a fewer number of synthetic variables (common factors) (Lomax, 1989). The relationships among the observed variables are determined by the covariances among the variables, found in variance/covariance (sometimes simply called, covariance) matrices. This matrix assumes that the unobserved variables are producing the pattern of relationship between the observed variables. A measurement model is utilized to link the unobserved latent or synthetic variables to the observed measured variables (Long, 1983). The structural model, in turn, specifies how the latent constructs are correlated with or influenced by other latent variables.

The Measurement Model

As noted previously, the aim of factor analysis is to explain the relationships between observed variables via common factors. The common factors are linear combinations of the measured variables that have substantive meaning. One way to specify the confirmatory factor analysis (CFA) model is by equation 3.10 from Jöreskog and Sörbom (1989, p. 97, illustrative subscripts added) in the context of population parameter matrices:

$$\Sigma_{(9 \times 9)} = \Lambda_{(9 \times 3)} \, \Phi_{(3 \times 3)} \, \Lambda'_{(3 \times 9)} + \theta_{(9 \times 9)} \quad (2\ [3.10])$$

where $\Lambda_{(9 \times 3)}$ is the factor pattern coefficient matrix, $\Phi_{(3 \times 3)}$ is the matrix of correlation coefficients among the three factors, $\theta_{(9 \times 9)}$ is

the unique variance in the measured variables (usually associated with measurement error in a correctly specified model) and the covariances of these errors, and $\Sigma_{(9 \times 9)}$ is the matrix of covariances or correlation coefficients among the nine measured or observed variables.

Two heuristic diagrams of measurement models are provided in Figure 1 and Figure 2 to clarify the relationships between the observed indicator variables (in Figure 1, variables named "V1" through "V12", conventionally denoted in the *squares*; in Figure 2, variables named "A1" through "C4"), the unobserved common factors (all latent/synthetic constructs are denoted by the *oval shapes*, by convention) and the error terms associated with each measured or observed indicator variable.

Insert Figure 1 and Figure 2 about here

An exploratory factor analysis imposes somewhat different specifications on the data (i.e., observed variables are a function of *all* the common factors, each observed variable is also partly a function of a unique factor, unique factors are always *uncorrelated*, and the common factors often are uncorrelated, as well) than a confirmatory factor analysis. In a confirmatory factor analysis, the researcher sets predetermined constraints on the model. For example the researcher may specify, (a) which observed variables are a function of which common factors, (b) which observed variables are a function of a unique factor, and (c) which common and which unique factors are correlated (Lomax, 1989). There are three major assumptions to accompany these specifications, (a)

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x (the observed variable(s)), ξ (the unobserved variable(s)), and δ (the error terms) are measured as deviations from their means, (b) q (observed) > n (unobserved), and (c) the common factors are uncorrelated with the unique factors (Long, 1983).

Model "identification" must be resolved before one can estimate the parameters of the model. Identification involves whether the parameters of the model can be uniquely determined or estimated based on the sample covariance matrix (S). If the model is not identified, then the parameters can not be uniquely defined, i.e., many different combinations of values can be placed into the above equation to equally well estimate the population covariance matrix Σ. So, by imposing constraints on the factor model, identification can be accomplished. If enough constraints are imposed on the model until only one set of values remain, then the model is said to be "identified" (Lomax, 1989). Of course, as Mulaik (1987) pointed out, allowing the parameters to be "fixed and freed" in a trial and error fashion until the model fits the data ignores the fact that the resulting model may or may not be meaningful.

The Structural Model

While the measurement model specifies how the latent or synthetic variables (i.e., hypothetical constructs) are measured in terms of observed variables, the structural model specifies the hypothesized casual relationships among the latent variables (Anderson, 1987). A distinction is made between two types of common factors, the latent independent variable (or latent exogenous variable) and latent dependent variables (or latent endogenous

variables). If we designate η_2 (m x 1) as a vector of the latent endogenous variables etas and ξ (n x 1) as a vector of the latent exogenous variables, then a system of linear structure equations is:

$$\eta_1 = B\ \eta_2 + \Gamma\xi + \zeta_e$$

where B (m x m) and Γ (m x n) are matrices of structure coefficients (or weights) relating the endogenous variables to one another and the exogenous variables to each other, and ζ (m x 1) is a residual (error or disturbance) vector (Anderson, 1987; Lomax, 1989). It is assumed that ζ is uncorrelated with ξ and that I - B is non-singular (Jöreskog, 1994). A heuristic diagram is provided in Figure 3 linking the two measurement models provided in Figures 1 and 2 and describing how the constructs impact upon each other.

Insert Figure 3 about here

To help clarify the above formula in relation to the structural model found in Figure 3, Figure 4 is provided showing the actualization of these abstract concepts. In Figure 4, type of attachment is hypothesized to impact psychological well-being. In this example, only depression will be utilized as representing well-being for the sake of clarity.

Insert Figure 4 about here

As can be seen in Figure 4, only a secure and ambivalent attachment affects depression. For illustrative purposes, the regression coefficients are shown on the paths going from these two attachment styles toward the construct of depression (secure = .4,

ambivalent = .2). If a path did not achieve a certain predetermined level of effect on the depression construct, then it would have been deleted from the final diagram.

Method of SEM

Parameter Estimation

Maximum-likelihood estimates of the model parameters can be generated by the LISREL computer program (Jöreskog & Sörbom, 1984) or other popular SEM computer packages (e.g., AMOS, EQS). LISREL has probably been the most widely used statistical program to estimate linear structural relationships among a set of variables, although for various reasons other packages are becoming increasingly popular. LISREL is designed to estimate parameters and test the validity of a wide range of models that contain measurement error, specification error, reciprocal causation, variables measured at several points in time, and latent (unobserved) variables (Anderson, 1987; Jöreskog, 1994).

Variance-covariance matrices or other matrices of association are analyzed by LISREL. The program outputs the parameter estimates derived using least squares, maximum-likelihood, or some other statistical theory.

Assessing Goodness of Fit

The squared correlation coefficient is computed for each structural equation. These consist of separate R^2s for each of the equations in the model. (These R^2s are different from the ones in regression in that they do not have an intercept term usually found in the output of regression models). A total coefficient of determination is computed for all the structural equations

simultaneously, for example in Figure 4, the equation would be expressed as:

Depression = Secure (.4) + Ambivalent (.2)....

This result indicates the amount of variance in the endogenous variables jointly accounted for by the model.

The LISREL model provides a chi-square statistic to test the fit of the model to the data. The chi-square statistic is a function of the difference between the observed covariance matrix and a predicted population matrix based on the model *and* sample size. To interpret the test, the residual covariance matrix that results when comparing the observed and predicted values is examined to see if it differs from zero. But because the chi-square statistic is also a function of sample size, then almost any model is likely to be rejected if the sample is large enough (Anderson, 1987).

Literally dozens of alternative fit statistics have been proposed. We are only beginning to understand (cf. Fan, Thompson & Wang, in press; Fan, Wang & Thompson, 1997) how these statistics perform under different conditions (e.g., degrees of multivariate normality, model specification) and what values may be reasonable for deeming that a model has adequate fit. Examples of the more common fit statistics used are provided in Table 1.

Insert Table 1 about here

In using fit statistics, the baseline model must first be employed. The baseline or null model (Bentler & Bonett, 1980) posits that the variables are mutually exclusive and that certain

variances and covariances are known. The baseline model is then used to determine how much of the observed variance-covariance matrix can be reproduced solely by the knowledge of zero-order correlations among the exogenous variables and the unique variances of the endogenous variables. The baseline or null model fit statistics are then used to calculate other fit statistics, as shown in Table 1.

In addition to the model chi square reported in Table 1, the Goodness of Fit Index (GFI), and the Adjusted Goodness of Fit Index (AGFI) are examples of other fit statistics, and also can be found in Table 1. The AGFI is adjusted for sample size. The Parsimony Ratio is used primarily to compare models; the more parameters estimated by a model, the less parsimonious is the model. The Parsimony Ratio can be used to weight other fit statistics to create an index that jointly considers both model fit and model parsimony. The CFI is compared to the null model to discern how the results compare to the null model. And finally, the Root Mean Square Residual (RMSR) and the Root Mean Square Error of Approximation (RMSEA) are important fit statistics. Desirable values for the fit statistics referenced in Table 1 are: GFI = >.9 or >.95; AGFI = > .9; the greater the value the parsimony ratio achieves, the better--if "0" is obtained, then there is no parsimony. For the CFI, values greater than .9 are desirable, and for the RMSEA, a value of less than .05 is optimal.

SEM and Canonical Correlation Analysis

Canonical correlation analysis (CCA) summarizes the relationship between two sets of variables. These two sets of

variables are linearly combined to produce pairs of synthetic variables (canonical variates) that have maximum bivariate correlation and are orthogonal to each other (Thompson, 1984, 1991). As mentioned earlier, CCA has been heralded as a unifying parametric statistical testing method for both univariate and multivariate problems (Fan, 1997), and *all* other univariate and multivariate parametric techniques can be subsumed under the auspices of CCA (Thompson, 1997). However, the present section illustrates that SEM subsumes CCA as an even more general statistical model. Using the same heuristic data set, a CCA will be performed, followed by a SEM, thereby concretely showing the greater generality of the SEM approach.

In the appendix, a CCA was applied to the Holzinger and Swineford (1939) data set. Utilizing variables T6 and T7 as dependent variables (found on physical page 2 of the appendix), and variables T2, T4, T20, T21, and T22 as the indicator variables (found on the Appendix pages labelled "Page 7" through "Page 10"), two functions result in this CCA as the number in the smaller set is two (Fan, 1997). The function coefficient for each variable is found in the **bolded** areas on the respective pages of the appendix, e.g., for T6, the function coefficients are .44962 and -1.40007 for function I and II respectively, and so on.

It will now be illustrated how the bolded canonical results can be reproduced as the corresponding bolded values from the SEM analysis also presented in the Appendix. The demonstration is a heuristic to show that SEM is the most general case of the general linear model (cf. Fan, 1996, 1997).

To apply a SEM, the PRELIS program found subsequently in the Appendix was first used to compute the correlation matrix. Then this correlation matrix from PRELIS was used to run four LISREL analyses, to reproduce the canonical function coefficients for both variables sets on both functions.

Note that the subsequent bolded four sets of LISREL coefficients for the "gamma" matrix exactly match (within rounding error) the canonical function coefficients presented previously in the printout. The only exception is that all the signs for the SEM second canonical function coefficients must be "reflected." "Reflecting" a function (changing *all* the signs on a given function, factor, or equation) is *always* permissible, because the scaling of psychological constructs is arbitrary. Thus, as can be seen from the data set found in the appendix, the SEM and the canonical analysis derived the same results.

Although this demonstration was primarily heuristic, to illustrate SEM's generality, there may also be some practical advantages to using SEM to compute canonical results. For example, within the SEM approach statistical significance testing of individual canonical function coefficients and structure coefficients is possible, and individual canonical coefficients can be tested (Fan, 1997). This is not readily accomplished in conventional canonical analysis (Thompson, 1984).

Conclusions

Structural equation modeling has become an increasingly popular statistical tool. Unfortunately, there is a direct positive correlation between statistical sophistication and the density and

abstractness of the methods employed. In that vein, a less recondite, almost rudimentary approach to structural equation modeling has been put forth through this paper. The basic tenets of structural equation modeling have been described and applied using heuristic path diagrams. Further, for the uninitiated, the formulas inherent in SEM have been operationalized and "tied" into their place in the diagrams. Lastly, to exemplify that SEM is the most general linear approach to statistics, a data set was used to juxtapose the CCA and the SEM approaches to analysis, thus deriving the exact same results.

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Table 1
Illustrative Model Fit Statistics

Statistic	Model #1	Model #2
v	18	18
n	780	780
Null chi sq	2519.24	2519.24
Null df	153	153
Noncentrality	2366.24	2366.24[a]
Model chi sq	205.78	748.95
Model df	128	135
Noncentrality	77.78	613.95[a]
NC / df	0.607656	4.547777[b]
GFI	0.960	0.699
Pars Ratio	0.748538	0.789473[c]
GFI*Pars	0.718596	0.551842[d]
CFI	0.967129	0.740537[e]
Pars Ratio	0.836601	0.882352[f]
CFI*Pars	0.809101	0.653415[g]
RMSR	0.005	0.199
RMSEA	0.000780	0.005837[h]

[a]Noncentrality = χ^2 - df

[b]Noncentrality / df

[c]Parsimony Ratio = Model df / [(variables * (variables + 1)) / 2]

[d]GFI * Parsimony Ratio

[e]$CFI = \frac{[(\text{Null } \chi^2 - \text{Null df}) - (\text{Model } \chi^2 - \text{Model df})]}{(\text{Null } \chi^2 - \text{Null df})}$

[f]Parsimony Ratio = Model df / [(variables * (variables - 1)) / 2]

[g]CFI * Parsimony Ratio

[h]$RMSEA = [(\text{Model } \chi^2 - \text{Model df}) / (\text{Model df} * (n - 1))]^{.5}$

Figure1.

ATTACHMENT MEASUREMENT MODEL

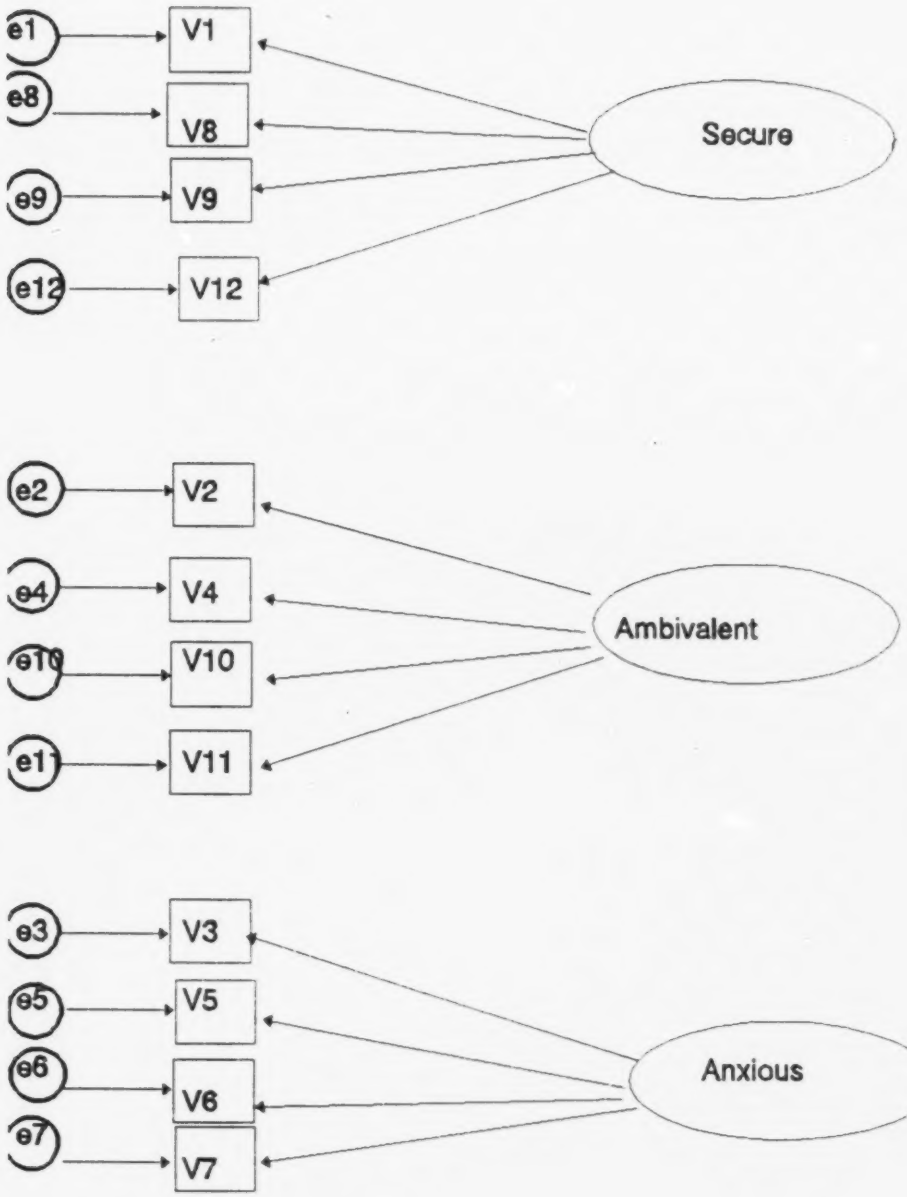
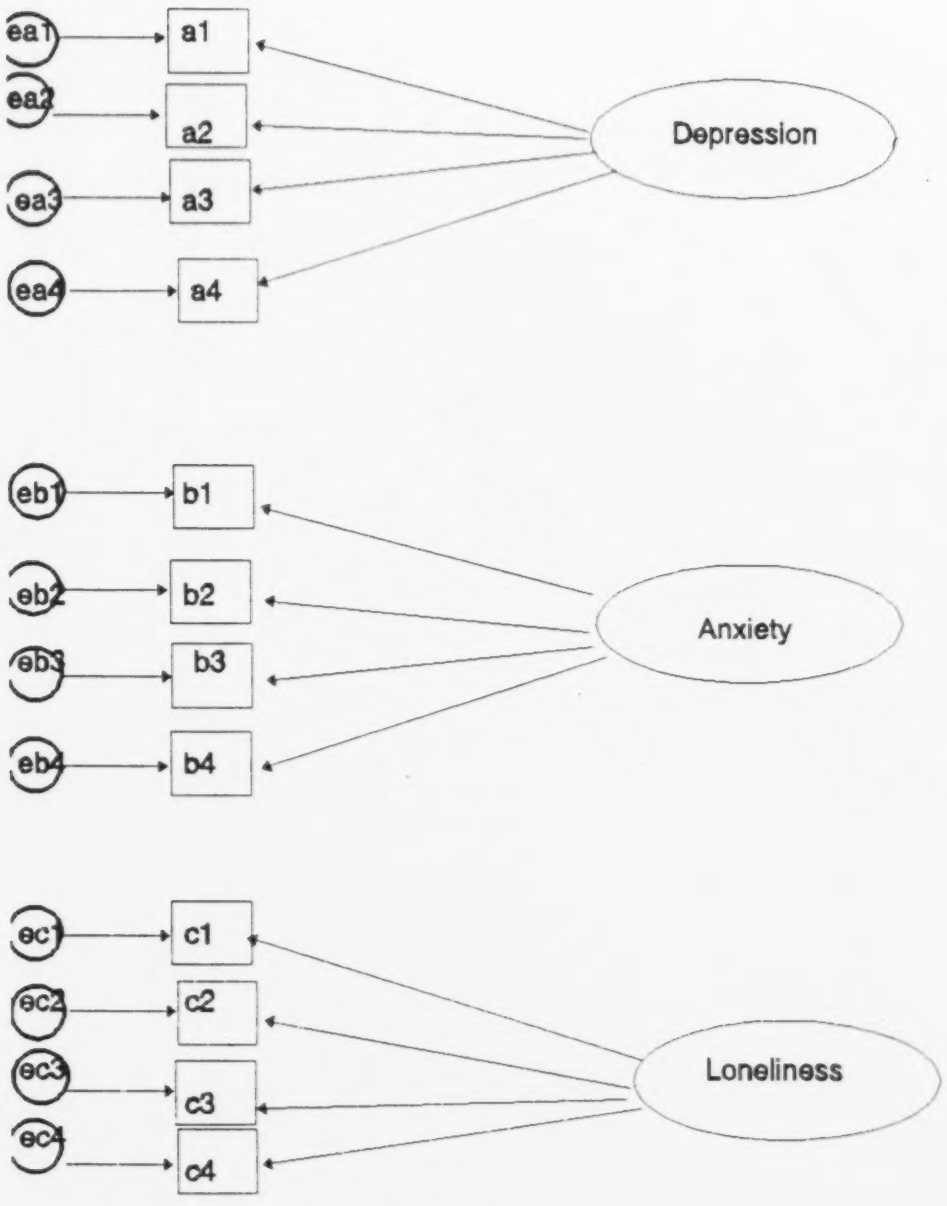


Figure 2.

WELL-BEING MEASUREMENT MODEL



STRUCTURAL MODEL

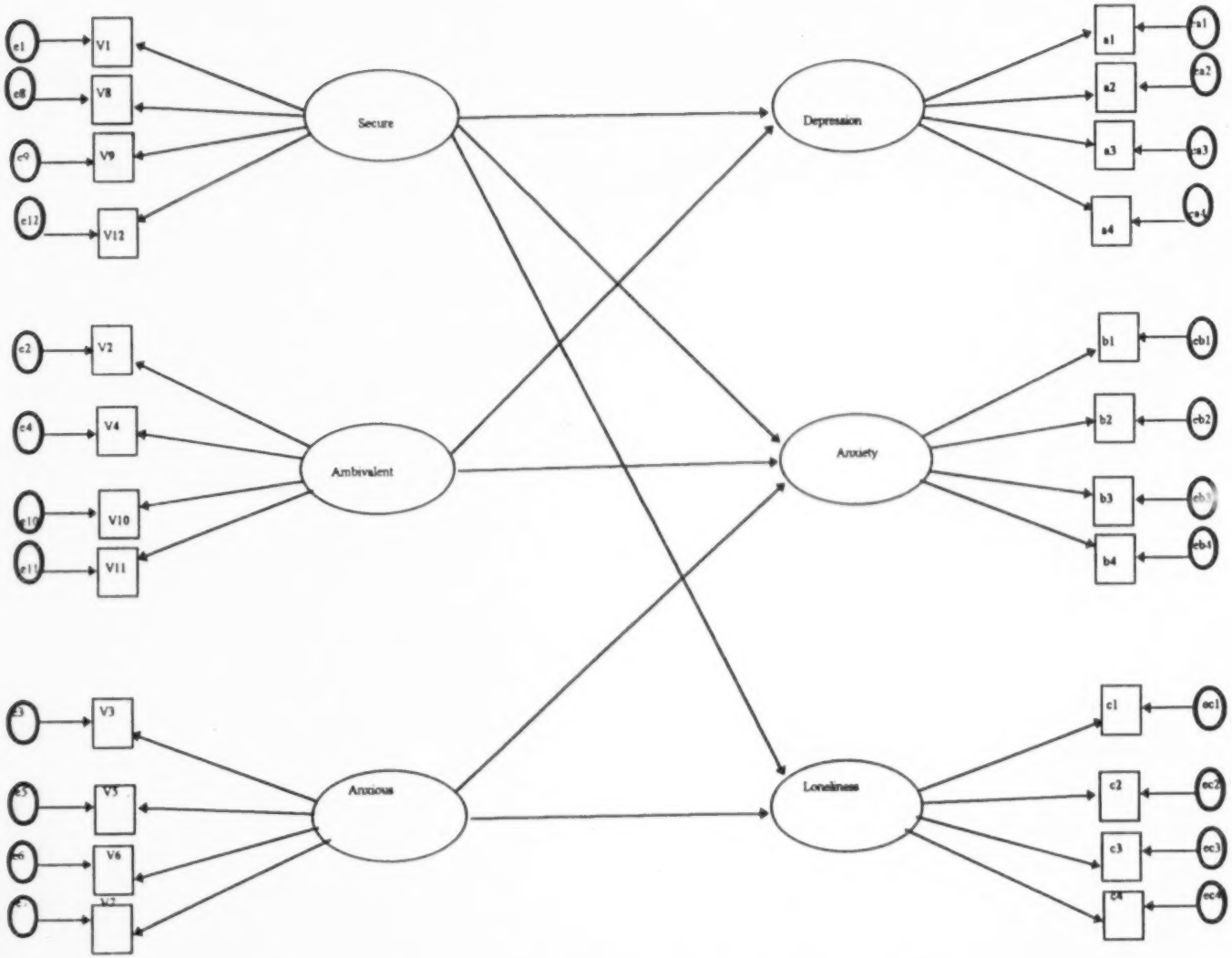


Figure 3.

STRUCTURAL MODEL

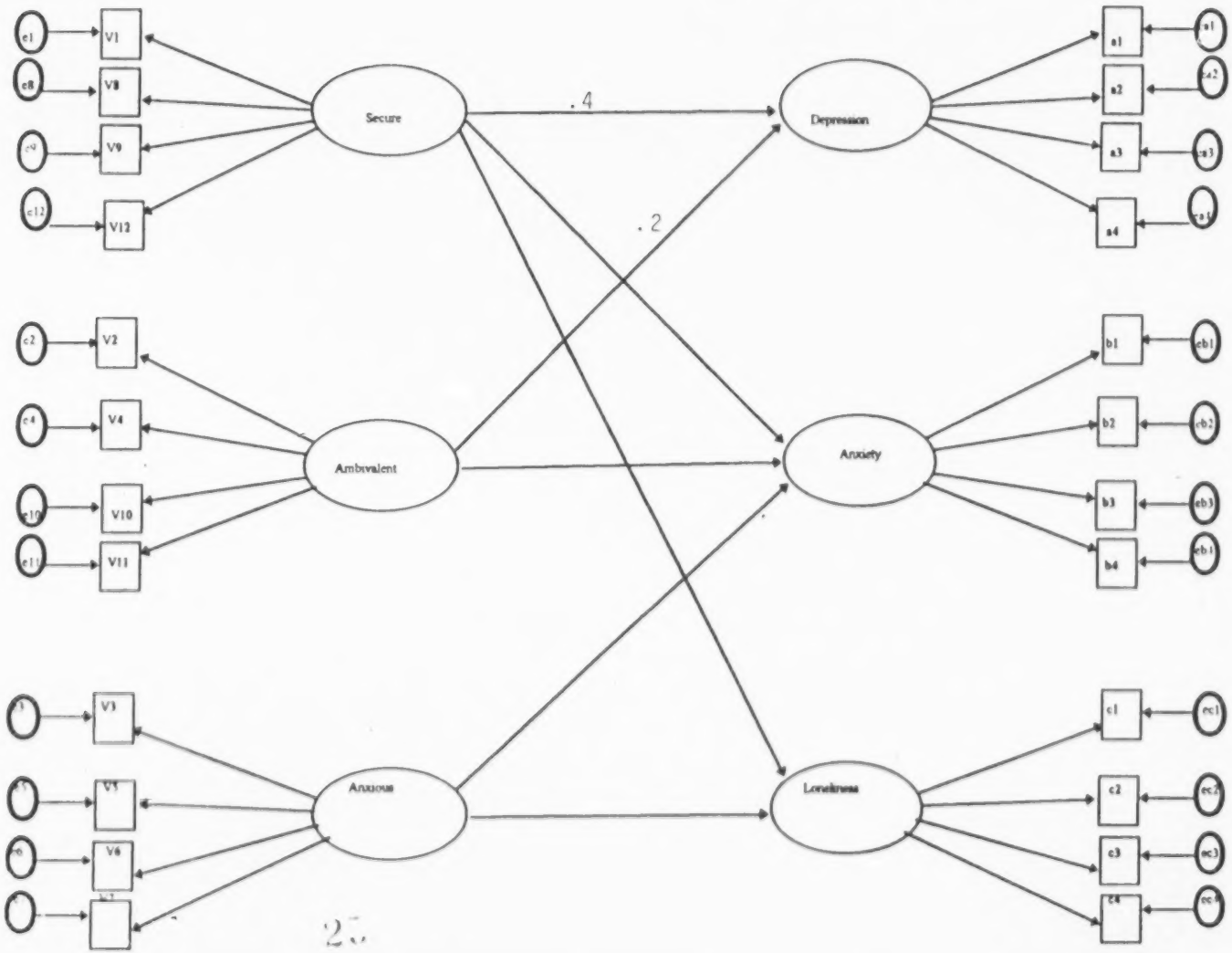


Figure 4.

APPENDIX
Illustration that SEM Subsumes CCA

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07-Dec-97   SPSS RELEASE 4.1 FOR IBM OS/MVS                                  Page   1
07:52:44    TEXAS A&M UNIVERSITY: CIS      IBM 3090-400J    MVS/ESA/JES3

For MVS/ESA/JES3        TEXAS A&M UNIVERSITY: CIS          License Number 1267
This software is functional through August 31, 1998.


   1  0  TITLE 'CANLISRL.SPS  Holzinger & Swineford (1939) Data **'.
   2  0  COMMENT ************************************************************.
   3  0  COMMENT Holzinger, K.J., & Swineford, F. (1939). A study in factor analysis:.
   4  0  COMMENT   The stability of a bi-factor solution (No. 48). Chicago, IL:.
   5  0  COMMENT   University of Chicago. (data on pp. 81-91).
   6  0  COMMENT ************************************************************.
   7  0  SET BLANKS=SYSMIS UNDEFINED=WARN.
   8  0  DATA LIST
   9  0    FILE=abc FIXED RECORDS=2 TABLE
  10  0    /1 id 1-3 sex 4-4 ageyr 6-7
  11  0    agemo 8-9 t1 11-12 t2 14-15 t3 17-18 t4 20-21 t5 23-24 t6 26-27 t7 29-30 t8
  12  0    32-33 t9 35-36 t10 38-40 t11 42-44 t12 46-48 t13 50-52 t14 54-56 t15 58-60
  13  0    t16 62-64 t17 66-67 t18 69-70 t19 72-73 t20 74-76 t21 78-79 /2 t22 11-12
  14  0    t23 14-15 t24 17-18 t25 20-21 t26 23-24 .
This command will read 2 records from 'E100BT.HOLZINGR.DTA'
Variable   Rec   Start     End          Format

ID           1       1       3         F3.0
SEX          1       4       4         F1.0
AGEYR        1       6       7         F2.0
AGEMO        1       8       9         F2.0
T1           1      11      12         F2.0
T2           1      14      15         F2.0
T3           1      17      18         F2.0
T4           1      20      21         F2.0
T5           1      23      24         F2.0
T6           1      26      27         F2.0
T7           1      29      30         F2.0
T8           1      32      33         F2.0
T9           1      35      36         F2.0
T10          1      38      40         F3.0
T11          1      42      44         F3.0
T12          1      46      48         F3.0
T13          1      50      52         F3.0
T14          1      54      56         F3.0
T15          1      58      60         F3.0
T16          1      62      64         F3.0
T17          1      66      67         F2.0
07-Dec-97   CANLISRL.SPS  Holzinger & Swineford (1939) Data **                Page   2
07:52:45    TEXAS A&M UNIVERSITY: CIS      IBM 3090-400J    MVS/ESA/JES3

T18          1      69      70         F2.0
T19          1      72      73         F2.0
T20          1      74      76         F3.0
T21          1      78      79         F2.0
T22          2      11      12         F2.0
T23          2      14      15         F2.0
T24          2      17      18         F2.0
T25          2      20      21         F2.0
T26          2      23      24         F2.0
  15  0  EXECUTE.
```

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```
  16  0  COMPUTE SCHOOL=1.
  17  0  IF (ID GT 200)SCHOOL=2.
  18  0  IF (ID GE 1 AND ID LE 85)GRADE=7.
  19  0  IF (ID GE 86 AND ID LE 168)GRADE=8.
  20  0  IF (ID GE 201 AND ID LE 281)GRADE=7.
  21  0  IF (ID GE 282 AND ID LE 351)GRADE=8.
  22  0  IF (ID GE 1 AND ID LE 44)TRACK=2.
  23  0  IF (ID GE 45 AND ID LE 85)TRACK=1.
  24  0  IF (ID GE 86 AND ID LE 129)TRACK=2.
  25  0  IF (ID GE 130)TRACK=1.
  26  0  PRINT FORMATS SCHOOL TO TRACK(F1.0).
  27  0  VALUE LABELS SCHOOL(1)PASTEUR (2) GRANT-WHITE/
  28  0    TRACK (1)JUNE PROMOTIONS (2)FEB PROMOTIONS/.
  29  0  VARIABLE LABELS T1 VISUAL PERCEPTION TEST FROM SPEARMAN VPT, PART III
  30  0    T2 CUBES, SIMPLIFICATION OF BRIGHAM'S SPATIAL RELATIONS TEST
  31  0    T3 PAPER FORM BOARD--SHAPES THAT CAN BE COMBINED TO FORM A TARGET
  32  0    T4 LOZENGES FROM THORNDIKE--SHAPES FLIPPED OVER THEN IDENTIFY TARGET
  33  0    T5 GENERAL INFORMATION VERBAL TEST
  34  0    T6 PARAGRAPH COMPREHENSION TEST
  35  0    T7 SENTENCE COMPLETION TEST
  36  0    T8 WORD CLASSIFICATION--WHICH WORD NOT BELONG IN SET
  37  0    T9 WORD MEANING TEST
  38  0    T10 SPEEDED ADDITION TEST
  39  0    T11 SPEEDED CODE TEST--TRANSFORM SHAPES INTO ALPHA WITH CODE
  40  0    T12 SPEEDED COUNTING OF DOTS IN SHAPE
  41  0    T13 SPEEDED DISCRIM STRAIGHT AND CURVED CAPS
  42  0    T14 MEMORY OF TARGET WORDS
  43  0    T15 MEMORY OF TARGET NUMBERS
  44  0    T16 MEMORY OF TARGET SHAPES
  45  0    T17 MEMORY OF OBJECT-NUMBER ASSOCIATION TARGETS
  46  0    T18 MEMORY OF NUMBER-OBJECT ASSOCIATION TARGETS
  47  0    T19 MEMORY OF FIGURE-WORD ASSOCIATION TARGETS
  48  0    T20 DEDUCTIVE MATH ABILITY
  49  0    T21 MATH NUMBER PUZZLES
  50  0    T22 MATH WORD PROBLEM REASONING
  51  0    T23 COMPLETION OF A MATH NUMBER SERIES
  52  0    T24 WOODY-MCCALL MIXED MATH FUNDAMENTALS TEST
  53  0    T25 REVISION OF T3--PAPER FORM BOARD
  54  0    T26 FLAGS--POSSIBLE SUBSTITUTE FOR T4 LOZENGES.
  55  0  SUBTITLE 'CCA ##############'.
07-Dec-97   CANLISRL.SPS  Holzinger & Swineford (1939) Data **          Page   3
07:52:45    CCA ##############

  56  0  correlations variables=t6 t7 t2 t4 t20 t21 t22/
  57  0    statistics=all .
PEARSON CORR problem requires 1,120 bytes of workspace.
07-Dec-97   CANLISRL.SPS  Holzinger & Swineford (1939) Data **          Page   4
07:52:45    CCA ##############
```

Variable	Cases	Mean	Std Dev
T6	301	9.1827	3.4923
T7	301	17.3621	5.1619
T2	301	24.3522	4.7098
T4	301	18.0033	9.0478
T20	301	26.8904	19.3339
T21	301	14.2492	4.5623
T22	301	26.2392	9.1972

Variables		Cases	Cross-Prod Dev	Variance-Covar	Variables		Cases	Cross-Prod Dev	Variance-Covar
T6	T7	301	3965.0831	13.2169	T6	T2	301	754.6312	2.5154
T6	T4	301	1503.8173	5.0127	T6	T20	301	6969.0299	23.2301
T6	T21	301	1532.2957	5.1077	T6	T22	301	4312.8439	14.3761
T7	T2	301	1016.6146	3.3887	T7	T4	301	1081.6379	3.6055
T7	T20	301	10080.9502	33.6032	T7	T21	301	2133.8405	7.1128
T7	T22	301	6690.9269	22.3031	T2	T4	301	4344.6478	14.4822
T2	T20	301	7681.6213	25.6054	T2	T21	301	1568.5880	5.2286
T2	T22	301	3653.6445	12.1788	T4	T20	301	17017.1096	56.7237
T4	T21	301	4098.7508	13.6625	T4	T22	301	7643.7608	25.4792
T20	T21	301	10317.2226	34.3907	T20	T22	301	21056.8937	70.1896

```
T21     T22          301       4742.0598         15.8069
07-Dec-97    CANLISRL.SPS  Holzinger & Swineford (1939) Data **                    Page   6
07:52:45     CCA ###############

                        - -  Correlation Coefficients  - -

             T6          T7          T2          T4          T20         T21         T22

T6          1.0000       .7332**     .1529**     .1586**     .3440**     .3206**     .4476**
T7           .7332**    1.0000       .1394*      .0772       .3367**     .3020**     .4698**
T2           .1529**     .1394*     1.0000       .3398**     .2812**     .2433**     .2812**
T4           .1586**     .0772       .3398**    1.0000       .3243**     .3310**     .3062**
T20          .3440**     .3367**     .2812**     .3243**    1.0000       .3899**     .3947**
T21          .3206**     .3020**     .2433**     .3310**     .3899**    1.0000       .3767**
T22          .4476**     .4698**     .2812**     .3062**     .3947**     .3767**    1.0000
* - Signif. LE .05     ** - Signif. LE .01     (2-tailed)          " . " printed if a
coefficient cannot be computed
07-Dec-97    CANLISRL.SPS  Holzinger & Swineford (1939) Data **                    Page   7
07:52:45     CCA ###############

Preceding task required .07 seconds CPU time;  .21 seconds elapsed.

  58  0  manova t6 t7 with t2 t4 t20 t21 t22/
  59  0    print=signif(multiv eigen dimenr)/
  60  0    discrim=stan cor alpha(.999)/design .
  61  0
07-Dec-97    CANLISRL.SPS  Holzinger & Swineford (1939) Data **                    Page   8
07:52:45     CCA ###############


* * * * * * * * * * * * * * * * * * * A N A L Y S I S   O F   V A R I A N C E * * * * * * * * *
* * * * * * * *

       301 cases accepted.
         0 cases rejected because of out-of-range factor values.
         0 cases rejected because of missing data.
         1 non-empty cell.
         1 design will be processed.

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
- - - - - - - - - - - - - - - -
07-Dec-97    CANLISRL.SPS  Holzinger & Swineford (1939) Data **                    Page   9
07:52:46     CCA ###############


* * * * * * * * * * * * * * * * * * * A N A L Y S I S   O F   V A R I A N C E -- DESIGN   1 * *
* * * * * * * * * * * * * * * * *

 EFFECT .. WITHIN CELLS Regression
 Multivariate Tests of Significance (S = 2, M = 1 , N = 146 )

 Test Name                Value       Approx. F       Hypoth. DF        Error DF        Sig. of F

 Pillais                  .31623        11.08083            10.00          590.00             .000
 Hotellings               .44521        13.04463            10.00          586.00             .000
 Wilks                    .68860        12.05883            10.00          588.00             .000
 Roys                     .30014
 Note.. F statistic for WILK'S Lambda is exact.

 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 Eigenvalues and Canonical Correlations

 Root No.       Eigenvalue          Pct.       Cum. Pct.      Canon Cor.        Sq. Cor

        1           .42885      96.32657       96.32657          .54785           .30014
        2           .01635       3.67343      100.00000          .12685           .01609

 - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
 Dimension Reduction Analysis

 Roots              Wilks L.              F        Hypoth. DF        Error DF        Sig. of F

 1 TO 2               .68860       12.05883            10.00          588.00             .000
 2 TO 2               .98391        1.20614             4.00          295.00             .308
```

EFFECT .. WITHIN CELLS Regression (Cont.)
Univariate F-tests with (5,295) D. F.

Variable	Sq. Mul. R	Mul. R	Adj. R-sq.	Hypoth. MS	Error MS	F	Sig. of F
T6	.24924	.49924	.23652	182.39270	9.31182	19.58722	.000
T7	.27358	.52305	.26127	437.37920	19.68350	22.22060	.000

Standardized canonical coefficients for DEPENDENT variables
Function No.

Variable	1	2
T6	.44962	-1.40007
T7	.62246	1.33225

07-Dec-97 CANLISRL.SPS Holzinger & Swineford (1939) Data ** Page 10
07:52:46 CCA ##############

* * * * * * * * * * * * * * * * * A N A L Y S I S O F V A R I A N C E -- DESIGN 1 * * * * * * * * * * * * * * * * *

Correlations between DEPENDENT and canonical variables
Function No.

Variable	1	2
T6	.90599	-.42330
T7	.95211	.30576

Variance explained by canonical variables of DEPENDENT variables

CAN. VAR.	Pct Var DEP	Cum Pct DEP	Pct Var COV	Cum Pct COV
1	86.36628	86.36628	25.92187	25.92187
2	13.63372	100.00000	.21938	26.14126

Standardized canonical coefficients for COVARIATES
CAN. VAR.

COVARIATE	1	2
T2	-.01468	.06704
T4	-.20012	-1.00653
T20	.34100	-.02762
T21	.26772	-.17401
T22	.73104	.35974

Correlations between COVARIATES and canonical variables
CAN. VAR.

Covariate	1	2
T2	.28388	-.22399
T4	.21791	-.94015
T20	.66492	-.26099
T21	.60625	-.36609
T22	.90109	-.00605

Variance explained by canonical variables of the COVARIATES

CAN. VAR.	Pct Var DEP	Cum Pct DEP	Pct Var COV	Cum Pct COV
1	10.50305	10.50305	34.99398	34.99398
2	.36567	10.86872	22.72448	57.71846

```
07-Dec-97   CANLISRL.SPS  Holzinger & Swineford (1939) Data **
07:52:46    CCA ##############

11152 bytes of memory are needed for MANOVA execution.
07-Dec-97   CANLISRL.SPS  Holzinger & Swineford (1939) Data **
07:52:46    CCA ##############

Preceding task required .13 seconds CPU time;  1.08 seconds elapsed.

  62  0  SUBTITLE 'Function I   2nd Variate n=301 v=7'.
  63  0  execute .
Preceding task required .01 seconds CPU time;  .03 seconds elapsed.

  64  0  PRELIS
  65  0    /VARIABLES
  66  0    t2 (CO) t4 (CO) t20 (CO) t21 (CO) t22 (CO)
  67  0    t6 (CO) t7 (CO)
  68  0    /TYPE=CORRELATION
  69  0    /MATRIX=OUT(CR1)
Time stamp on saved file:  07-DEC-97 07:52:47
File contains 9 variables, 72 bytes per case before compression
There are 3,044,392 bytes of memory available.
The largest contiguous area has 3,037,808 bytes.


                    P R E L I S    A PREPROCESSOR FOR LISREL

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                            MVS - P R E L I S  1.12
                                    BY
                        KARL G JORESKOG AND DAG SORBOM


THE FOLLOWING PRELIS CONTROL LINES HAVE BEEN READ :


CANLISRL.SPS  HOLZINGER & SWINEFORD (1939) DATA **;
DA NI=7 NO=0 MI= -0.989898D+37 MC=1 TR=LI
LA
   T2         T4         T20        T21        T22        T6         T7
RA FI=PLDDRAW
CO T2
CO T4
CO T20
CO T21
CO T22
CO T6
CO T7
OU MA=KM SM=PLDDMAT WP

TOTAL SAMPLE SIZE =  301
UNIVARIATE SUMMARY STATISTICS FOR CONTINUOUS VARIABLES
VARIABLE      MEAN    ST. DEV.   SKEWNESS   KURTOSIS   MINIMUM FREQ.   MAXIMUM FREQ.
--------  --------  ---------  ---------  ---------  --------- -----  --------- -----
      T2    24.352      4.710      0.475      0.377     9.000     1     37.000     5
      T4    18.003      9.048      0.387     -0.879     2.000     1     36.000     6
     T20    26.890     19.334      0.493      0.199   -18.000     1     87.000     2
     T21    14.249      4.562     -0.311      0.140     1.000     1     24.000     2
     T22    26.239      9.197      0.409     -0.188     7.000     2     50.000     5
      T6     9.183      3.492      0.270      0.122     0.000     1     19.000     1
      T7    17.362      5.162     -0.353     -0.520     4.000     2     28.000     1
```

```
CANLISRL.SPS  HOLZINGER & SWINEFORD (1939) DATA **;
       ESTIMATED CORRELATION MATRIX
                T2          T4          T20         T21         T22         T6          T7
          ________    ________    ________    ________    ________    ________    ________
      T2     1.000
      T4     0.340       1.000
     T20     0.281       0.324       1.000
     T21     0.243       0.331       0.390       1.000
     T22     0.281       0.306       0.395       0.377       1.000
      T6     0.153       0.159       0.344       0.321       0.448       1.000
      T7     0.139       0.077       0.337       0.302       0.470       0.733       1.000
          THE PROBLEM USED     94552 BYTES (=  3.1% OF AVAILABLE WORKSPACE)
07-Dec-97   CANLISRL.SPS  Holzinger & Swineford (1939) Data **
07:52:48    Function I   2nd Variate n=301 v=7

Preceding task required .71 seconds CPU time;  1.86 seconds elapsed.

  70  0  LISREL
  71  0    /"1b  First Function   n=301 v=7"
  72  0    /DA NI=7 NO=301 MA=KM
  73  0    /MATRIX=IN(CR1)
  74  0    /MO BE=ZE PS=ZE TD=ZE LX=ID LY=FU,FI TE=SY,FR
  75  0     GA=FU,FI PH=SY,FR NX=2 NY=5 NK=2 NE=1
  76  0    /VA 1.0 PH(1,1) PH(2,2)
  77  0    /VA 1.0 LY(1,1)
  78  0    /FR LY(2,1) LY(3,1) LY(4,1) LY(5,1)
  79  0    /FR GA(1,1) GA(1,2)
  80  0    /OU SS FS SL=1 TM=1200 ND=5
There are 3,036,568 bytes of memory available.
The largest contiguous area has 3,030,440 bytes.


                  LISREL 7:  ESTIMATION OF LINEAR STRUCTURAL EQUATION SYSTEMS
                          PROGRAM VERSION 7.16       DISTRIBUTED BY

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                           MVS - L I S R E L  7.16
                                   BY
                       KARL G JORESKOG AND DAG SORBOM

THE FOLLOWING LISREL CONTROL LINES HAVE BEEN READ :

1b  First Function   n=301 v=7
DA NI=7 NO=301 MA=KM
KM FI=LSDDDTA FO
(5E14.6)
LA
 T2       T4       T20      T21      T22      T6       T7
MO BE=ZE PS=ZE TD=ZE LX=ID LY=FU,FI TE=SY,FR   C
  GA=FU,FI PH=SY,FR NX=2 NY=5 NK=2 NE=1
VA 1.0 PH(1,1) PH(2,2)
VA 1.0 LY(1,1)
FR LY(2,1) LY(3,1) LY(4,1) LY(5,1)
FR GA(1,1) GA(1,2)
OU SS FS SL=1 TM=1200 ND=5
1b  First Function   n=301 v=7
                         NUMBER OF INPUT VARIABLES  7
                         NUMBER OF Y - VARIABLES    5
                         NUMBER OF X - VARIABLES    2
                         NUMBER OF ETA - VARIABLES  1
                         NUMBER OF KSI - VARIABLES  2
                         NUMBER OF OBSERVATIONS   301
1b  First Function   n=301 v=7
```

CORRELATION MATRIX TO BE ANALYZED

	T2	T4	T20	T21	T22	T6	T7
T2	1.00000						
T4	0.33986	1.00000					
T20	0.28121	0.32427	1.00000				
T21	0.24334	0.33099	0.38990	1.00000			
T22	0.28116	0.30619	0.39474	0.37672	1.00000		
T6	0.15293	0.15864	0.34405	0.32058	0.44758	1.00000	
T7	0.13939	0.07720	0.33672	0.30204	0.46980	0.73319	1.00000

1b First Function n=301 v=7

PARAMETER SPECIFICATIONS

LAMBDA Y

	ETA 1
T2	0
T4	1
T20	2
T21	3
T22	4

GAMMA

	T6	T7
ETA 1	5	6

PHI

	T6	T7
T6	7	
T7	8	9

THETA EPS

	T2	T4	T20	T21	T22
T2	10				
T4	11	12			
T20	13	14	15		
T21	16	17	18	19	
T22	20	21	22	23	24

1b First Function n=301 v=7

INITIAL ESTIMATES (TSLS)

LAMBDA Y

	ETA 1
T2	1.00000
T4	1.17397
T20	1.18343
T21	1.16531
T22	1.14421

GAMMA

	T6	T7
ETA 1	0.00000	0.00000

COVARIANCE MATRIX OF ETA AND KSI

	ETA 1	T6	T7
ETA 1	0.00000		
T6	0.00000	1.00000	
T7	0.00000	0.73319	1.00000

THETA EPS

	T2	T4	T20	T21	T22
T2	1.00000				
T4	0.33986	1.00000			
T20	0.28121	0.32427	1.00000		
T21	0.24334	0.33099	0.38990	1.00000	
T22	0.28116	0.30619	0.39474	0.37672	1.00000

SQUARED MULTIPLE CORRELATIONS FOR Y - VARIABLES

T2	T4	T20	T21	T22
0.00000	0.00000	0.00000	0.00000	0.00000

TOTAL COEFFICIENT OF DETERMINATION FOR Y - VARIABLES IS 0.000

1b First Function n=301 v=7

LISREL ESTIMATES (MAXIMUM LIKELIHOOD)

LAMBDA Y

	ETA 1
T2	*1.00000*
T4	*0.76757*
T20	*2.34225*
T21	*2.13559*
T22	*3.17417*

GAMMA

	T6	*T7*
ETA 1	*0.06992*	*0.09682*

COVARIANCE MATRIX OF ETA AND KSI

	ETA 1	T6	T7
ETA 1	0.02419		
T6	0.14091	1.00000	
T7	0.14808	0.73319	1.00000

THETA EPS

	T2	T4	T20	T21	T22
T2	0.97581				
T4	0.32129	0.98575			
T20	0.22455	0.28079	0.86730		
T21	0.19169	0.29134	0.26891	0.88968	
T22	0.20438	0.24726	0.21490	0.21275	0.75629

SQUARED MULTIPLE CORRELATIONS FOR Y - VARIABLES

T2	T4	T20	T21	T22
0.02419	0.01425	0.13270	0.11032	0.24371

TOTAL COEFFICIENT OF DETERMINATION FOR Y - VARIABLES IS 0.300

CHI-SQUARE WITH 4 DEGREES OF FREEDOM = 4.87 (P = .301)
GOODNESS OF FIT INDEX =0.995
ADJUSTED GOODNESS OF FIT INDEX =0.968
ROOT MEAN SQUARE RESIDUAL = 0.013

```
1b  First Function   n=301 v=7
SUMMARY STATISTICS FOR FITTED RESIDUALS
SMALLEST FITTED RESIDUAL =   -0.036
  MEDIAN FITTED RESIDUAL =    0.000
 LARGEST FITTED RESIDUAL =    0.050
STEMLEAF PLOT
- 3|6
- 2|
- 1|40
- 0|900000000000000000000
  0|
  1|24
  2|0
  3|
  4|
  5|0
SUMMARY STATISTICS FOR STANDARDIZED RESIDUALS
SMALLEST STANDARDIZED RESIDUAL =   -2.117
  MEDIAN STANDARDIZED RESIDUAL =    0.000
 LARGEST STANDARDIZED RESIDUAL =    2.117
STEMLEAF PLOT
- 2|1
- 1|
- 1|0
- 0|85
- 0|000000000000000000000
  0|
  0|58
  1|0
  1|
```

```
  2|1
1b  First Function   n=301 v=7
FACTOR SCORES REGRESSIONS
        ETA
                T2          T4          T20         T21         T22         T6          T7

   ETA 1    0.00000     0.00000     0.00000     0.00000     0.00000     0.06992     0.09682
        X
                T2          T4          T20         T21         T22         T6          T7

      T6    0.00000     0.00000     0.00000     0.00000     0.00000     1.00000     0.00000
      T7    0.00000     0.00000     0.00000     0.00000     0.00000     0.00000     1.00000
1b  First Function   n=301 v=7
STANDARDIZED SOLUTION
        LAMBDA Y
              ETA 1

      T2     0.15553
      T4     0.11938
     T20     0.36428
     T21     0.33214
     T22     0.49367

         GAMMA
                    T6          T7

    ETA 1      0.44957     0.62250

        CORRELATION MATRIX OF ETA AND KSI
              ETA 1          T6          T7

   ETA 1     1.00000
      T6     0.90598     1.00000
      T7     0.95212     0.73319     1.00000
        REGRESSION MATRIX ETA ON X (STANDARDIZED)
                T6          T7

   ETA 1     0.44957     0.62250
        THE PROBLEM USED     7704 BYTES (=    0.3% OF AVAILABLE WORKSPACE)
                          TIME USED :     0.00 SECONDS
07-Dec-97   CANLISRL.SPS  Holzinger & Swineford (1939) Data **
07:52:50    Function I   2nd Variate n=301 v=7

Preceding task required .44 seconds CPU time;  1.41 seconds elapsed.

  81  0  SUBTITLE 'Function I   1st Variate n=301 v=7'.
  82  0  execute .
Preceding task required .01 seconds CPU time;  .03 seconds elapsed.

  83  0  PRELIS
  84  0    /VARIABLES
  85  0    t6 (CO) t7 (CO)
  86  0    t2 (CO) t4 (CO) t20 (CO) t21 (CO) t22 (CO)
  87  0    /TYPE=CORRELATION
  88  0    /MATRIX=OUT(CR2)
Time stamp on saved file:  07-DEC-97 07:52:50
File contains 9 variables, 72 bytes per case before compression
There are 3,041,056 bytes of memory available.
The largest contiguous area has 3,030,872 bytes.


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                          MVS - P R E L I S  1.12
                                   BY
                        KARL G JORESKOG AND DAG SORBOM


THE FOLLOWING PRELIS CONTROL LINES HAVE BEEN READ :


CANLISRL.SPS  HOLZINGER & SWINEFORD (1939) DATA **;
DA NI=7 NO=0 MI= -0.989898D+37 MC=1 TR=LI
LA
   T6        T7        T2        T4        T20       T21       T22
RA FI=PLDDRAW
CO T6
CO T7
CO T2
CO T4
CO T20
CO T21
CO T22
OU MA=KM SM=PLDDMAT WP

TOTAL SAMPLE SIZE =  301
UNIVARIATE SUMMARY STATISTICS FOR CONTINUOUS VARIABLES
VARIABLE      MEAN  ST. DEV.  SKEWNESS  KURTOSIS  MINIMUM FREQ.  MAXIMUM FREQ.
_______ _________ _________ _________ _________ _________ _____ _________ _____
     T6     9.183     3.492     0.270     0.122     0.000     1    19.000     1
     T7    17.362     5.162    -0.353    -0.520     4.000     2    28.000     1
     T2    24.352     4.710     0.475     0.377     9.000     1    37.000     5
     T4    18.003     9.048     0.387    -0.879     2.000     1    36.000     6
    T20    26.890    19.334     0.493     0.199   -18.000     1    87.000     2
    T21    14.249     4.562    -0.311     0.140     1.000     1    24.000     2
    T22    26.239     9.197     0.409    -0.188     7.000     2    50.000     5
CANLISRL.SPS  HOLZINGER & SWINEFORD (1939) DATA **;
        ESTIMATED CORRELATION MATRIX
               T6        T7        T2        T4        T20       T21       T22
_______ _________ _________ _________ _________ _________ _________ _________
     T6     1.000
     T7     0.733     1.000
     T2     0.153     0.139     1.000
     T4     0.159     0.077     0.340     1.000
    T20     0.344     0.337     0.281     0.324     1.000
    T21     0.321     0.302     0.243     0.331     0.390     1.000
    T22     0.448     0.470     0.281     0.306     0.395     0.377     1.000
         THE PROBLEM USED     94344 BYTES (=  3.1% OF AVAILABLE WORKSPACE)
07-Dec-97   CANLISRL.SPS  Holzinger & Swineford (1939) Data **
07:52:52    Function I    1st Variate n=301 v=7

Preceding task required .72 seconds CPU time;  1.86 seconds elapsed.

  89  0  LISREL
  90  0    /"1a  First Function   n=301 v=7"
  91  0    /DA NI=7 NO=301 MA=KM
  92  0    /MATRIX=IN(CR2)
  93  0    /MO BE=ZE PS=ZE TD=ZE LX=ID LY=FU,FI TE=SY,FR
  94  0     GA=FU,FI PH=SY,FR NX=5 NY=2 NK=5 NE=1
  95  0    /VA 1.0 PH(1,1) PH(2,2) PH(3,3) PH(4,4) PH(5,5)
  96  0    /VA 1.0 LY(1,1)
  97  0    /FR LY(2,1)
  98  0    /FR GA(1,1) GA(1,2) GA(1,3) GA(1,4) GA(1,5)
  99  0    /OU SS FS SL=1 TM=1200 ND=5
 100  0
There are 3,032,512 bytes of memory available.
The largest contiguous area has 3,026,376 bytes.


                LISREL 7:  ESTIMATION OF LINEAR STRUCTURAL EQUATION SYSTEMS
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```

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MVS - L I S R E L 7.16

BY

KARL G JORESKOG AND DAG SORBOM

THE FOLLOWING LISREL CONTROL LINES HAVE BEEN READ :

```
la  First Function   n=301 v=7
DA NI=7 NO=301 MA=KM
KM FI=LSDDDTA FO
(5E14.6)
LA
 T6       T7       T2       T4       T20      T21      T22
MO BE=ZE PS=ZE TD=ZE LX=ID LY=FU,FI TE=SY,FR   C
  GA=FU,FI PH=SY,FR NX=5 NY=2 NK=5 NE=1
VA 1.0 PH(1,1) PH(2,2) PH(3,3) PH(4,4) PH(5,5)
VA 1.0 LY(1,1)
FR LY(2,1)
FR GA(1,1) GA(1,2) GA(1,3) GA(1,4) GA(1,5)
OU SS FS SL=1 TM=1200 ND=5
```

la First Function n=301 v=7

NUMBER OF INPUT VARIABLES	7
NUMBER OF Y - VARIABLES	2
NUMBER OF X - VARIABLES	5
NUMBER OF ETA - VARIABLES	1
NUMBER OF KSI - VARIABLES	5
NUMBER OF OBSERVATIONS	301

la First Function n=301 v=7

CORRELATION MATRIX TO BE ANALYZED

	T6	T7	T2	T4	T20	T21	T22
T6	1.00000						
T7	0.73319	1.00000					
T2	0.15293	0.13939	1.00000				
T4	0.15864	0.07720	0.33986	1.00000			
T20	0.34405	0.33672	0.28121	0.32427	1.00000		
T21	0.32058	0.30204	0.24334	0.33099	0.38990	1.00000	
T22	0.44758	0.46980	0.28116	0.30619	0.39474	0.37672	1.00000

la First Function n=301 v=7

PARAMETER SPECIFICATIONS

LAMBDA Y

	ETA 1
T6	0
T7	1

GAMMA

	T2	T4	T20	T21	T22
ETA 1	2	3	4	5	6

PHI

	T2	T4	T20	T21	T22
T2	7				
T4	8	9			
T20	10	11	12		
T21	13	14	15	16	
T22	17	18	19	20	21

THETA EPS

	T6	T7
T6	22	

```
     T7          23          24
1a'  First Function    n=301 v=7

...

LISREL ESTIMATES (MAXIMUM LIKELIHOOD)
        LAMBDA Y
                ETA 1

       T6        1.00000
       T7        1.05093
         GAMMA
                    T2          T4          T20         T21         T22

   ETA 1       -0.00729    -0.09934     0.16926     0.13288     0.36285

...

STANDARDIZED SOLUTION
        LAMBDA Y
               ETA 1

       T6      0.49635
       T7      0.52163

          GAMMA
                    T2          T4          T20         T21         T22

   ETA 1       -0.01468    -0.20014     0.34100     0.26772     0.73104

        CORRELATION MATRIX OF ETA AND KSI
               ETA 1          T2          T4          T20         T21         T22

   ETA 1       1.00000
      T2       0.28388     1.00000
      T4       0.21790     0.33986     1.00000
     T20       0.66492     0.28121     0.32427     1.00000
     T21       0.60626     0.24334     0.33099     0.38990     1.00000
     T22       0.90109     0.28116     0.30619     0.39474     0.37672     1.00000
        REGRESSION MATRIX ETA ON X (STANDARDIZED)
                   T2          T4          T20         T21         T22

   ETA 1       -0.01468    -0.20014     0.34100     0.26772     0.73104
        THE PROBLEM USED     8616 BYTES (=    0.3% OF AVAILABLE WORKSPACE)
                          TIME USED :     0.00 SECONDS
07-Dec-97    CANLISRL.SPS  Holzinger & Swineford (1939) Data **
07:52:53     Function I    1st Variate n=301 v=7

Preceding task required .41 seconds CPU time;  1.40 seconds elapsed.

 101  0  SUBTITLE 'Function II  2nd Variate n=301 v=7'.
 102  0  execute .
Preceding task required .01 seconds CPU time;  .03 seconds elapsed.

 103  0  LISREL
 104  0    /"2b  Second Function  n=301 v=7"
 105  0    /DA NI=7 NO=301 MA=KM
 106  0    /MATRIX=IN(CR1)
 107  0    /MO BE=ZE PS=ZE TD=ZE LX=ID LY=FU,FI TE=SY,FR
 108  0     GA=FU,FI PH=SY,FR NX=2 NY=5 NK=2 NE=2
 109  0    /VA 1.0 PH(1,1) PH(2,2)
 110  0    /VA 1.0 LY(1,1) LY(1,2)
 111  0      /VA 0.76757 LY(2,1)
 112  0      /VA 2.34225 LY(3,1)
 113  0      /VA 2.13559 LY(4,1)
 114  0      /VA 3.17417 LY(5,1)
 115  0    /FR LY(2,2) LY(3,2) LY(4,2) LY(5,2)
```

```
 116  0     /VA 0.06992 GA(1,1)
 117  0     /VA 0.09682 GA(1,2)
 118  0    /FR GA(2,1) GA(2,2)
 119  0    /OU SS FS SL=1 TM=1200 ND=5
There are 3,027,680 bytes of memory available.
The largest contiguous area has 3,021,552 bytes.

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                                BY
                    KARL G JORESKOG AND DAG SORBOM


THE FOLLOWING LISREL CONTROL LINES HAVE BEEN READ :


2b  Second Function  n=301 v=7
DA NI=7 NO=301 MA=KM
KM FI=LSDDDTA FO
(5E14.6)
LA
 T2       T4       T20      T21      T22      T6       T7
MO BE=ZE PS=ZE TD=ZE LX=ID LY=FU,FI TE=SY,FR   C
  GA=FU,FI PH=SY,FR NX=2 NY=5 NK=2 NE=2
VA 1.0 PH(1,1) PH(2,2)
VA 1.0 LY(1,1) LY(1,2)
VA 0.76757 LY(2,1)
VA 2.34225 LY(3,1)
VA 2.13559 LY(4,1)
VA 3.17417 LY(5,1)
FR LY(2,2) LY(3,2) LY(4,2) LY(5,2)
VA 0.06992 GA(1,1)
VA 0.09682 GA(1,2)
FR GA(2,1) GA(2,2)
OU SS FS SL=1 TM=1200 ND=5
2b  Second Function  n=301 v=7
                        NUMBER OF INPUT VARIABLES  7
                        NUMBER OF Y - VARIABLES    5
                        NUMBER OF X - VARIABLES    2
                        NUMBER OF ETA - VARIABLES  2
                        NUMBER OF KSI - VARIABLES  2
                        NUMBER OF OBSERVATIONS   301
2b  Second Function  n=301 v=7
        CORRELATION MATRIX TO BE ANALYZED
                T2          T4          T20         T21         T22         T6          T7
        --------    --------    --------    --------    --------    --------    --------
 T2      1.00000
 T4      0.33986     1.00000
T20      0.28121     0.32427     1.00000
T21      0.24334     0.33099     0.38990     1.00000
T22      0.28116     0.30619     0.39474     0.37672     1.00000
 T6      0.15293     0.15864     0.34405     0.32058     0.44758     1.00000
 T7      0.13939     0.07720     0.33672     0.30204     0.46980     0.73319     1.00000
2b  Second Function  n=301 v=7
PARAMETER SPECIFICATIONS
        LAMBDA Y
              ETA 1       ETA 2
```

```
          T2             0             0
          T4             0             1
         T20             0             2
         T21             0             3
         T22             0             4
           GAMMA
                        T6            T7

      ETA 1             0             0
      ETA 2             5             6
           PHI
                        T6            T7

          T6             7
          T7             8             9
           THETA EPS
                        T2            T4            T20           T21           T22

          T2            10
          T4            11            12
         T20            13            14            15
         T21            16            17            18            19
         T22            20            21            22            23            24
2b  Second Function  n=301 v=7

...

STANDARDIZED SOLUTION
           LAMBDA Y
                    ETA 1         ETA 2

          T2      0.15553       0.02842
          T4      0.11938       0.11927
         T20      0.36429       0.03311
         T21      0.33215       0.04645
         T22      0.49368       0.00077

           GAMMA
                        T6            T7

      ETA 1      0.44956       0.62251
      ETA 2      1.40013      -1.33228

           CORRELATION MATRIX OF ETA AND KSI
                    ETA 1         ETA 2            T6            T7

      ETA 1      1.00000
      ETA 2     -0.00001       1.00000
         T6      0.90598       0.42332       1.00000
         T7      0.95212      -0.30572       0.73319       1.00000
           REGRESSION MATRIX ETA ON X (STANDARDIZED)
                        T6            T7

      ETA 1      0.44956       0.62251
      ETA 2      1.40013      -1.33228
           THE PROBLEM USED     8072 BYTES (=   0.3% OF AVAILABLE WORKSPACE)
                          TIME USED :    0.00 SECONDS
07-Dec-97   CANLISRL.SPS  Holzinger & Swineford (1939) Data **
07:52:54    Function II  2nd Variate n=301 v=7

Preceding task required .63 seconds CPU time;  1.45 seconds elapsed.

 120  0  SUBTITLE 'Function II  1st Variate n=301 v=7'.
 121  0  execute .
Preceding task required .01 seconds CPU time;  .03 seconds elapsed.

 122  0  LISREL
 123  0    /"2a  Second Function  n=301 v=7"
 124  0    /DA NI=7 NO=301 MA=KM
 125  0    /MATRIX=IN(CR2)
```

```
 126  0     /MO BE=ZE PS=ZE TD=ZE LX=ID LY=FU,FI TE=SY,FR
 127  0      GA=FU,FI PH=SY,FR NX=5 NY=2 NK=5 NE=2
 128  0     /VA 1.0 PH(1,1) PH(2,2) PH(3,3) PH(4,4) PH(5,5)
 129  0     /VA 1.0 LY(1,1) LY(1,2)
 130  0       /VA 1.05093 LY(2,1)
 131  0     /FR LY(2,2)
 132  0       /VA -.00729 GA(1,1)
 133  0       /VA -.09934 GA(1,2)
 134  0       /VA 0.16926 GA(1,3)
 135  0       /VA 0.13288 GA(1,4)
 136  0       /VA 0.36285 GA(1,5)
 137  0     /FR GA(2,1) GA(2,2) GA(2,3) GA(2,4) GA(2,5)
 138  0     /OU SS FS SL=1 TM=1200 ND=5
 139  0
There are 3,024,192 bytes of memory available.
The largest contiguous area has 3,018,040 bytes.


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                                   BY
                      KARL G JORESKOG AND DAG SORBOM


THE FOLLOWING LISREL CONTROL LINES HAVE BEEN READ :


2a  Second Function  n=301 v=7
DA NI=7 NO=301 MA=KM
KM FI=LSDDDTA FO
(5E14.6)
LA
 T6       T7       T2       T4       T20      T21      T22
MO BE=ZE PS=ZE TD=ZE LX=ID LY=FU,FI TE=SY,FR   C
  GA=FU,FI PH=SY,FR NX=5 NY=2 NK=5 NE=2
VA 1.0 PH(1,1) PH(2,2) PH(3,3) PH(4,4) PH(5,5)
VA 1.0 LY(1,1) LY(1,2)
VA 1.05093 LY(2,1)
FR LY(2,2)
VA -.00729 GA(1,1)
VA -.09934 GA(1,2)
VA 0.16926 GA(1,3)
VA 0.13288 GA(1,4)
VA 0.36285 GA(1,5)
FR GA(2,1) GA(2,2) GA(2,3) GA(2,4) GA(2,5)
OU SS FS SL=1 TM=1200 ND=5
2a  Second Function  n=301 v=7
                         NUMBER OF INPUT VARIABLES  7
                         NUMBER OF Y - VARIABLES    2
                         NUMBER OF X - VARIABLES    5
                         NUMBER OF ETA - VARIABLES  2
                         NUMBER OF KSI - VARIABLES  5
                         NUMBER OF OBSERVATIONS   301
2a  Second Function  n=301 v=7
        CORRELATION MATRIX TO BE ANALYZED
                 T6         T7         T2         T4         T20        T21        T22
        --------   --------   --------   --------   --------   --------   --------
```


BEST COPY AVAILABLE

T6	1.00000						
T7	0.73319	1.00000					
T2	0.15293	0.13939	1.00000				
T4	0.15864	0.07720	0.33986	1.00000			
T20	0.34405	0.33672	0.28121	0.32427	1.00000		
T21	0.32058	0.30204	0.24334	0.33099	0.38990	1.00000	
T22	0.44758	0.46980	0.28116	0.30619	0.39474	0.37672	1.00000

2a Second Function n=301 v=7

PARAMETER SPECIFICATIONS

LAMBDA Y

	ETA 1	ETA 2
T6	0	0
T7	0	1

GAMMA

	T2	T4	T20	T21	T22
ETA 1	0	0	0	0	0
ETA 2	2	3	4	5	6

PHI

	T2	T4	T20	T21	T22
T2	7				
T4	8	9			
T20	10	11	12		
T21	13	14	15	16	
T22	17	18	19	20	21

THETA EPS

	T6	T7
T6	22	
T7	23	24

2a Second Function n=301 v=7

...

STANDARDIZED SOLUTION

LAMBDA Y

	ETA 1	ETA 2
T6	0.49635	0.05370
T7	0.52163	-0.03878

GAMMA

	T2	**T4**	**T20**	**T21**	**T22**
ETA 1	**-0.01469**	**-0.20014**	**0.34101**	**0.26771**	**0.73104**
ETA 2	**-0.06706**	**1.00653**	**0.02762**	**0.17402**	**-0.35972**

CORRELATION MATRIX OF ETA AND KSI

	ETA 1	ETA 2	T2	T4	T20	T21	T22
ETA 1	1.00000						
ETA 2	0.00001	1.00000					
T2	0.28387	0.22399	1.00000				
T4	0.21790	0.94015	0.33986	1.00000			
T20	0.66493	0.26101	0.28121	0.32427	1.00000		
T21	0.60625	0.36611	0.24334	0.33099	0.38990	1.00000	
T22	0.90109	0.00607	0.28116	0.30619	0.39474	0.37672	1.00000

REGRESSION MATRIX ETA ON X (STANDARDIZED)

	T2	T4	T20	T21	T22
ETA 1	-0.01469	-0.20014	0.34101	0.26771	0.73104
ETA 2	-0.06706	1.00653	0.02762	0.17402	-0.35972

THE PROBLEM USED 9480 BYTES (= 0.3% OF AVAILABLE WORKSPACE)

TIME USED : 0.00 SECONDS

07-Dec-97 CANLISRL.SPS Holzinger & Swineford (1939) Data **

07:52:56 Function II 1st Variate n=301 v=7